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THE EX-MERIDIAN CALCULATOR.

BY

JAMES SMITH, Master Mariner.

Complete Tables for finding the Latitude by an Ex-Meridian Altitude of the Sun, Planet or Star, within the Latitudes and Declinations of 81° North and South, and within all practical limits of Hour Angle.

By using these Tables, the correct Latitude can be obtained by observing Stars at twilight when they are near the Meridian, and when the horizon is then quite clear.

Seventh and extended Edition.

PRICE—FOUR SHILLINGS.

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Table 1.

HOUR ANGLE NUMBERS.

Table 2. cont.

0 HOUR							1 HOUR							ASTRONOMY LIBRARY LAT. AND DEC. Numbers.						
Min.	0'	10'	20'	30'	40'	50'	Min.	0'	10'	20'	30'	40'	50'	Deg.	0'	10'	20'	30'	40'	50'
0			4856	4503	4254	4060	0	348	346	343	340	338	336	21	30	30	31	31	32	32
1	3901	3767	3652	3549	3458	3375	1	333	331	329	326	324	322	22	33	33	34	34	35	35
2	3299	3230	3165	3106	3049	2997	2	319	317	315	312	310	308	23	36	37	37	38	38	39
3	2947	2900	2856	2813	2773	2734	3	305	303	301	299	296	294	24	39	40	40	41	42	42
4	2697	2662	2628	2595	2563	2533	4	292	290	287	285	283	281	25	43	43	44	45	45	46
5	2503	2475	2447	2421	2395	2370	5	278	276	274	272	270	267	26	46	47	48	48	49	49
6	2345	2321	2298	2276	2254	2232	6	265	263	261	259	257	254	27	50	51	51	52	53	53
7	2211	2191	2171	2151	2132	2114	7	252	250	248	246	244	242	28	54	55	55	56	57	57
8	2095	2077	2060	2043	2026	2009	8	240	237	235	233	231	229	29	58	59	60	60	61	62
9	1993	1977	1961	1946	1931	1916	9	227	225	223	221	219	217	30	62	63	64	65	65	66
10	1901	1887	1873	1859	1845	1832	10	215	213	210	208	206	204	31	67	68	68	69	70	71
11	1819	1806	1793	1780	1767	1755	11	202	200	198	196	194	192	32	72	72	73	74	75	76
12	1743	1731	1719	1708	1696	1685	12	190	188	186	184	182	180	33	76	77	78	79	80	81
13	1674	1663	1652	1641	1630	1620	13	178	176	174	173	171	169	34	81	82	83	84	85	86
14	1609	1599	1589	1579	1569	1559	14	167	165	163	161	159	157	35	87	88	88	89	90	91
15	1549	1540	1530	1521	1512	1502	15	155	153	151	149	148	146	36	92	93	94	95	96	97
16	1493	1484	1475	1467	1458	1449	16	144	142	140	138	136	134	37	98	99	100	101	102	102
17	1441	1432	1424	1416	1407	1399	17	132	131	129	127	125	123	38	103	104	105	106	107	108
18	1391	1383	1375	1367	1359	1352	18	121	120	118	116	114	112	39	109	111	112	113	114	115
19	1344	1337	1329	1322	1314	1307	19	110	109	107	105	103	101	40	116	117	118	119	120	121
20	1300	1292	1285	1278	1271	1264	20	100	98	96	94	92	91	41	122	123	124	126	127	128
21	1257	1250	1244	1237	1230	1223	21	89	87	85	84	82	80	42	129	130	131	132	134	135
22	1217	1210	1204	1197	1191	1185	22	78	77	75	73	71	70	43	136	137	138	139	141	142
23	1178	1172	1166	1160	1154	1147	23	68	66	65	63	61	59	44	143	144	146	147	148	149
24	1141	1135	1129	1123	1118	1112	24	58	56	54	53	51	49	45	151	152	153	154	156	157
25	1106	1100	1094	1089	1083	1077	25	48	46	44	43	41	39	46	158	160	161	162	164	165
26	1072	1066	1061	1055	1050	1045	26	37	36	34	33	31	29	47	166	168	169	170	172	173
27	1039	1034	1029	1023	1018	1013	27	28	26	24	23	21	19	48	174	176	177	179	180	182
28	1008	1002	997	992	987	982	28	18	16	15	13	11	10	49	183	185	186	187	189	190
29	977	972	967	962	957	953	29	8	6	5	3	2	0	50	192	193	195	196	198	200
30	948	943	938	933	929	924	Note.—The Hour Angle in Minutes must not exceed the Meridian Zenith Distance in Degrees.							51	201	203	204	206	207	209
31	919	915	910	905	901	896								52	211	212	214	216	217	219
32	892	887	883	878	874	870								53	221	222	224	226	227	229
33	865	861	856	852	848	843								54	231	233	234	236	238	240
34	839	835	831	826	822	818	TABLE 2. LAT. and DEC. Numbers							55	241	243	245	247	249	251
35	814	810	806	802	798	794								56	252	254	256	258	260	262
36	790	786	782	778	774	770	Deg. 0' 10' 20' 30' 40' 50'							57	264	266	268	270	272	274
37	766	762	758	754	750	747								58	276	278	280	282	284	286
38	743	739	735	731	728	724	59	288	290	292	295	297	299							
39	720	717	713	709	706	702	60	301	303	305	308	310	312							
40	698	695	691	688	684	681	1	0	0	0	0	0	0	61	314	317	319	321	324	326
41	677	673	670	666	663	660	2	0	0	0	0	0	1	62	328	331	333	336	338	340
42	656	653	649	646	642	639	3	1	1	1	1	1	1	63	343	345	348	350	353	356
43	636	632	629	626	622	619	4	1	1	1	1	1	2	64	358	361	363	366	369	371
44	616	613	609	606	603	600	5	2	2	2	2	2	2	65	374	377	380	382	385	388
45	596	593	590	587	584	580	6	2	3	3	3	3	3	66	391	394	396	399	402	405
46	577	574	571	568	565	562	7	3	3	4	4	4	4	67	408	411	414	417	420	423
47	559	556	553	550	547	544	8	4	4	5	5	5	5	68	426	430	433	436	439	442
48	541	538	535	532	529	526	9	5	6	6	6	6	6	69	446	449	452	456	459	462
49	523	520	517	514	511	508	10	7	7	7	7	8	8	70	466	469	473	477	480	484
50	505	502	499	497	494	491	11	8	8	9	9	9	9	71	487	491	495	499	502	506
51	488	485	482	480	477	474	12	10	10	10	10	11	11	72	510	514	518	522	526	530
52	471	468	466	463	460	457	13	11	12	12	12	12	13	73	534	538	542	547	551	555
53	455	452	449	447	444	441	14	13	13	14	14	14	15	74	560	564	569	573	578	582
54	439	436	433	431	428	425	15	15	15	16	16	16	17	75	587	592	597	601	606	611
55	423	420	418	415	412	410	16	17	18	18	18	19	19	76	616	621	627	632	637	642
56	407	403	402	399	397	394	17	19	20	20	21	21	21	77	648	653	659	665	670	676
57	392	389	387	384	382	379	18	22	22	23	23	23	24	78	682	688	694	700	707	713
58	377	373	372	369	367	365	19	24	25	25	26	26	27	79	719	726	733	739	746	753
59	362	360	357	355	352	350	20	27	27	28	28	29	29	80	760	768	775	782	790	798

Table 3.

ALTITUDE NUMBERS.

Table 4.

ALTITUDE.							ALTITUDE.							ANGLE.			
Deg.	0'	10'	20'	30'	40'	50'	Deg.	0'	10'	20'	30'	40'	50'	Mins.	37°	38°	39°
5	1282	1281	1281	1281	1281	1281	66	888	885	882	879	876	874	0	1445	1621	1922
6	1281	1281	1280	1280	1280	1280	67	871	868	865	861	858	855	1	1447	1624	1930
7	1280	1279	1279	1279	1279	1279	68	852	849	846	843	839	836	2	1450	1628	1937
8	1279	1278	1278	1278	1278	1278	69	833	830	826	823	819	816	3	1452	1632	1944
9	1277	1277	1277	1277	1277	1276	70	812	809	805	802	798	795	4	1454	1636	1952
10	1276	1276	1276	1275	1275	1275	71	791	787	784	780	776	772	5	1457	1639	1960
11	1274	1274	1274	1274	1273	1273	72	768	764	760	756	752	748	6	1459	1643	1968
12	1273	1273	1272	1272	1272	1271	73	744	740	736	732	727	723	7	1462	1647	1976
13	1271	1271	1270	1270	1270	1269	74	719	714	710	705	700	696	8	1464	1651	1984
14	1269	1269	1268	1268	1268	1267	75	691	686	682	677	672	667	9	1467	1655	1992
15	1267	1267	1266	1266	1266	1265	76	662	657	651	646	641	636	10	1470	1659	2001
16	1265	1265	1264	1264	1263	1263	77	630	625	619	613	608	602	11	1472	1663	2010
17	1263	1262	1262	1261	1261	1261	78	596	590	584	578	572	566	12	1475	1667	2019
18	1260	1260	1259	1259	1258	1258	79	559	553	546	539	532	525	13	1477	1671	2028
19	1257	1257	1257	1256	1256	1255	80	518	511	503	496	488	480	14	1480	1675	2037
20	1255	1254	1254	1253	1253	1252	81	473	464	456	448	439	431	15	1483	1679	2047
21	1252	1251	1251	1250	1250	1249	82	422	413	404	394	384	374	16	1485	1683	2057
22	1249	1248	1248	1247	1246	1246	83	364	354	343	332	321	309	17	1488	1687	2067
23	1245	1245	1244	1244	1243	1243	84	297	285	272	259	246	232	18	1490	1691	2077
24	1242	1241	1241	1240	1240	1239	85	218	203	188	172	156	139	19	1493	1696	2087
25	1238	1238	1237	1237	1236	1235	86	121	103	83	63	42	20	20	1496	1700	2098
26	1235	1234	1233	1233	1232	1232	Sun's Altitude Correction (Add).							21	1499	1704	2109
27	1231	1230	1230	1229	1228	1228	Height of Eye in Feet.							22	1501	1709	2120
28	1227	1226	1225	1225	1224	1223	Alt.							23	1504	1713	2132
29	1223	1222	1221	1221	1220	1219		15	20	30	40	50	65	24	1507	1718	2144
30	1218	1218	1217	1216	1215	1215	6	3.9	3.3	2.3	1.5	0.7		25	1510	1722	2156
31	1214	1213	1212	1211	1211	1210	7	5.0	4.4	3.4	2.6	1.9	0.9	26	1512	1727	2169
32	1209	1208	1207	1207	1206	1205	8	5.8	5.3	4.3	3.5	2.7	1.7	27	1515	1732	2181
33	1204	1203	1203	1202	1201	1200	9	6.5	6.0	5.0	4.1	3.4	2.4	28	1518	1736	2195
34	1199	1198	1197	1196	1195	1195	10	7.1	6.5	5.5	4.7	4.0	3.0	29	1521	1741	2209
35	1194	1193	1192	1191	1190	1189	12	8.0	7.4	6.4	5.5	4.8	3.9	30	1524	1746	2223
36	1188	1187	1186	1186	1185	1184	14	8.6	8.0	7.0	6.2	5.5	4.5	31	1527	1751	2238
37	1183	1182	1181	1180	1179	1178	16	9.1	8.5	7.5	6.7	5.9	5.0	32	1530	1756	2253
38	1177	1176	1175	1174	1173	1172	20	9.7	9.2	8.2	7.3	6.6	5.6	33	1533	1760	2269
39	1171	1170	1169	1168	1166	1165	24	10.2	9.6	8.6	7.8	7.1	6.1	34	1536	1765	2285
40	1164	1163	1162	1161	1160	1159	30	10.7	10.1	9.1	8.3	7.6	6.6	35	1539	1771	2302
41	1158	1157	1156	1154	1153	1152	40	11.2	10.6	9.6	8.8	8.0	7.1	36	1542	1776	2320
42	1151	1150	1149	1148	1146	1145	60	11.7	11.1	10.1	9.3	8.6	7.7	37	1545	1781	2338
43	1144	1143	1142	1140	1139	1138	90	12.2	11.6	10.6	9.8	9.1	8.1	38	1548	1786	2358
44	1137	1135	1134	1133	1132	1130	Star's Altitude Correction (Subt.)							39	1551	1792	2378
45	1129	1128	1127	1125	1124	1123	Height of Eye in Feet.							40	1554	1797	2399
46	1121	1120	1119	1118	1116	1115	Alt.							41	1557	1802	2421
47	1113	1112	1111	1109	1108	1106		15	20	30	40	50	65	42	1560	1808	2445
48	1105	1104	1102	1101	1099	1098	6	12.3	12.9	13.9	14.7	15.4	16.4	43	1563	1814	2470
49	1096	1095	1093	1092	1090	1089	7	11.2	11.8	12.8	13.6	14.3	15.3	44	1566	1819	2496
50	1087	1086	1084	1083	1081	1080	8	10.4	11.0	12.0	12.8	13.5	14.5	45	1570	1825	2524
51	1078	1077	1075	1073	1072	1070	9	9.7	10.3	11.3	12.1	12.8	13.8	46	1573	1831	2554
52	1069	1067	1065	1064	1062	1060	10	9.1	9.7	10.7	11.5	12.3	13.2	47	1576	1837	2586
53	1059	1057	1055	1053	1052	1050	12	8.3	8.9	9.8	10.7	11.4	12.4	48	1579	1843	2621
54	1048	1046	1045	1043	1041	1040	14	7.6	8.2	9.2	10.0	10.8	11.7	49	1583	1849	2659
55	1038	1036	1034	1032	1030	1029	16	7.1	7.7	8.7	9.5	10.3	11.2	50	1586	1855	2700
56	1027	1025	1023	1021	1019	1017	20	6.4	7.0	8.1	8.8	9.6	10.5	51	1589	1861	2746
57	1015	1013	1011	1009	1007	1005	24	6.0	6.5	7.5	8.4	9.1	10.1	52	1593	1867	2797
58	1003	1001	999	997	995	993	30	5.5	6.1	7.0	7.9	8.6	9.6	53	1596	1874	2855
59	991	989	987	984	982	980	40	5.0	5.5	6.5	7.3	8.1	9.0	54	1600	1880	2922
60	978	976	974	971	969	967	60	4.4	5.0	5.9	6.8	7.5	8.5	55	1603	1887	3001
61	964	962	960	958	955	953	90	3.8	4.4	5.4	6.2	6.9	7.9	56	1607	1894	3098
62	950	948	946	943	941	938								57	1610	1901	3223
63	936	933	931	928	926	923								58	1614	1908	3399
64	921	918	915	913	910	907								59	1617	1915	3700
65	905	902	899	896	894	891								60	1621	1922	Infinite.

RULES AND EXAMPLES.

To work an ex-meridian of the Sun, Planet or Star:—

Correct the observed Altitude by adding the Sun's correction, or subtracting the Star's correction.

Take from the Tables numbers corresponding to the Hour Angle, Latitude by account, Declination and True Altitude. Add these four numbers together. From Table 4 take out the Angle corresponding to the sum of the numbers. From this Angle subtract the True Altitude. The remainder will be the Meridian Zenith Distance. Apply the Declination in the usual way, and the Latitude found will be the Latitude at the time of the observation.

EXAMPLE.—Hour Angle oh 30m, Latitude by account $40^{\circ} 10' N.$, Declination $10^{\circ} 0' S.$, True Altitude $39^{\circ} 20' S.$

Hour Angle number	...	948.	Angle, Table 4	...	$89^{\circ} 31'$
Lat. by acc. do.	...	117	True Altitude	...	$39 \quad 20 \text{ S.}$
Declination do.	...	7	Meridian Zenith Dist.	50	11 N.
True Altitude do.	...	1169	Declination	...	$10 \quad 00 \text{ S.}$
		<u>2241</u>	Latitude	...	<u>$40^{\circ} 11' N.$</u>

$2241, \text{ Table } 4 = \text{Angle } 89^{\circ} 31'$

If an Altitude near the meridian be observed *below* the pole, find the Angle in Table 4 as above. From this Angle subtract the Declination, and to the remainder add the Altitude. This sum will be the Latitude at the time of the observation.

EXAMPLE.—Hour Angle 43m 48s, Latitude by acc. $54^{\circ} 10' S.$, Declination $60^{\circ} 23' S.$ True Altitude of $\alpha \text{ Centauri}$ below the pole $24^{\circ} 55'$.

Hour Angle number	...	619	Angle, Table 4	...	$89^{\circ} 40'$
Latitude by acc. do.	...	233	Declination	...	$60^{\circ} 23 \text{ S.}$
Declination do.	...	306			<u>$29 \quad 17$</u>
True Altitude do.	...	1239	True Altitude	...	$24 \quad 55$
		<u>2397</u>	Latitude	...	<u>$54^{\circ} 12' S.$</u>

$2397, \text{ Table } 4 = \text{Angle } 89^{\circ} 40'$